Advanced IMPRINT Workshop

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You will be able to…

◆ Develop an advanced analysis using Advanced or Goal-oriented options

◆ Interpret results to complete analysis

◆ Demonstrate Advanced Workload techniques

◆ Demonstrate Goal Matrix programming

◆ Identify opportunities for use of IMPRINT capabilities

Development of Analysis

OR

D . O . A

Many Variables

Concept System

Too Dangerous

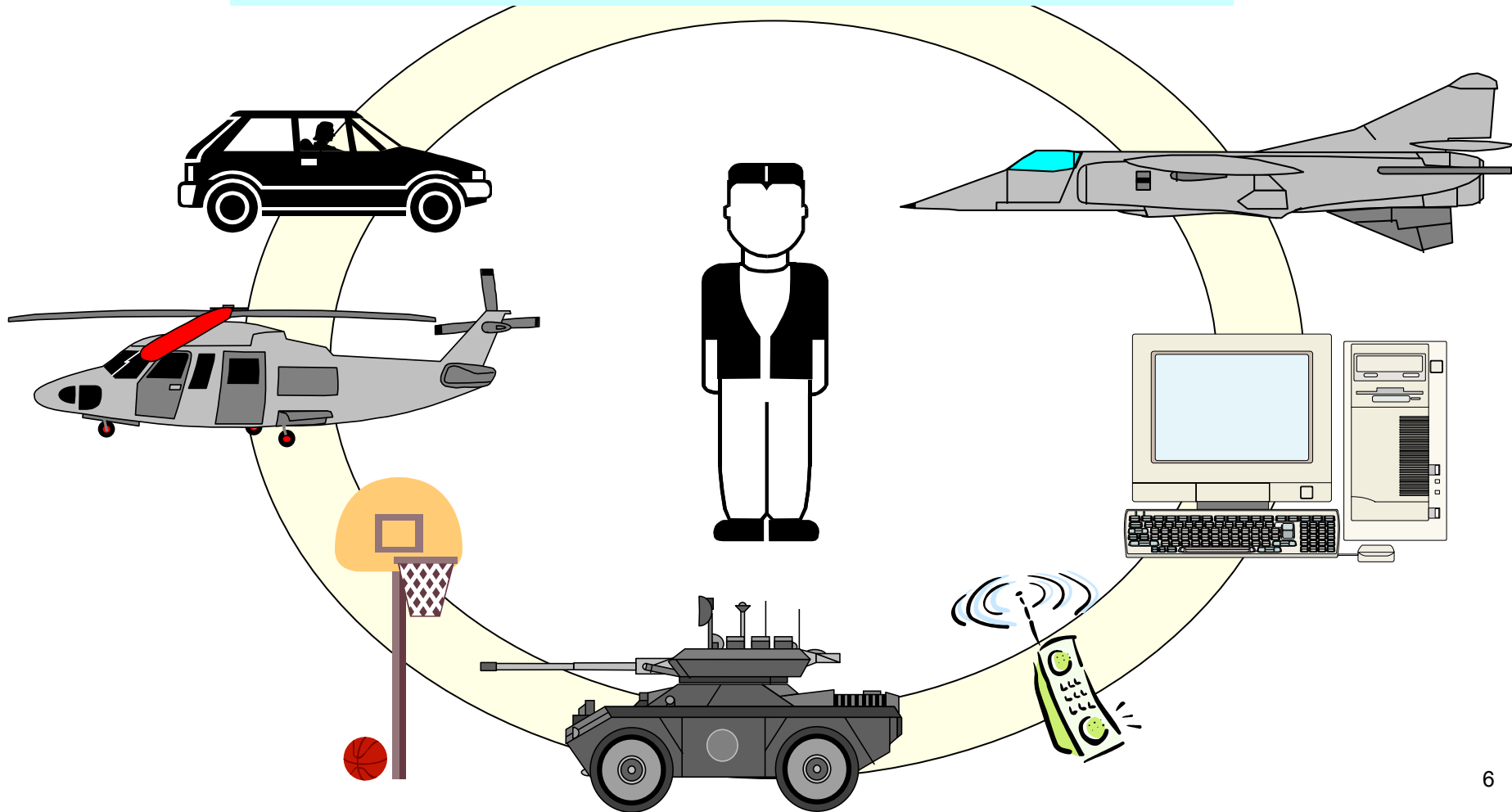Field Study Not Feasible

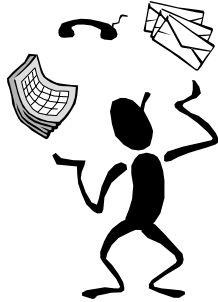**Model – Test – Model**

System Performance = f(human performance)
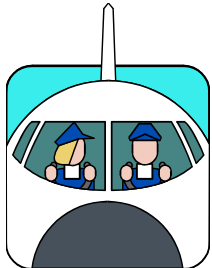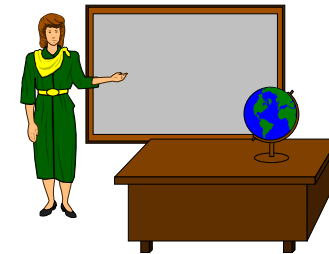
Is the human overloaded with tasks?

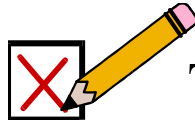Will training improve human and system performance?

How to allocate tasks between human(s) and automation?

What are the performance tradeoffs with different system designs or levels of operator experience?

Task time and accuracy
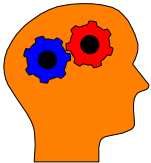
Operator workload level

Number of operators required

Impact on System Performance

Clear questions

Appropriate measures
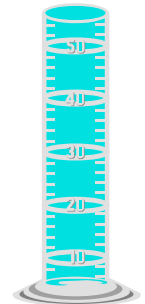
Details, details, details
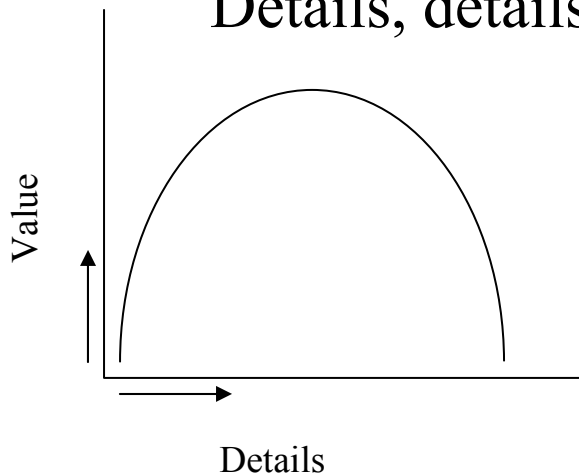
Input data collection

Value

Details

◆ Determine the problem - What is your question? Observation!

◆ Make a hypothesis - What is your prediction?

◆ Test your hypothesis - What steps and measures are necessary? What tool?

◆ Analyze your results

◆ Draw conclusions

McLauglin, C.W. and Thompson, M. (1999). Physical Science. Columbus, OH: Glencoe/McGraw-Hill.
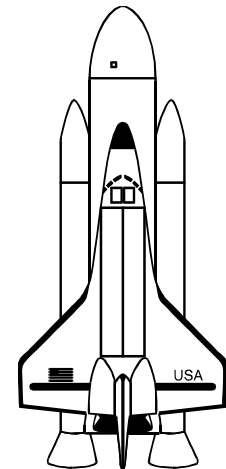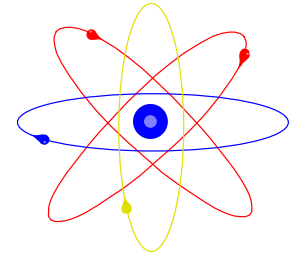
IMPRINT Review

The IMPRINT Directory

◆ ## What's in it

- – Executable files, & DLL files
- – IMPRINT database files
  - » "library" files - stuff that "comes with" IMPRINT
  - » "user" files - your stuff
  - » "working" or "session" files - for the open analysis
- – Report files - linked to an analysis
- – Help files
- – Documentation & Readme
  - » Analysis Guide & User's Guide
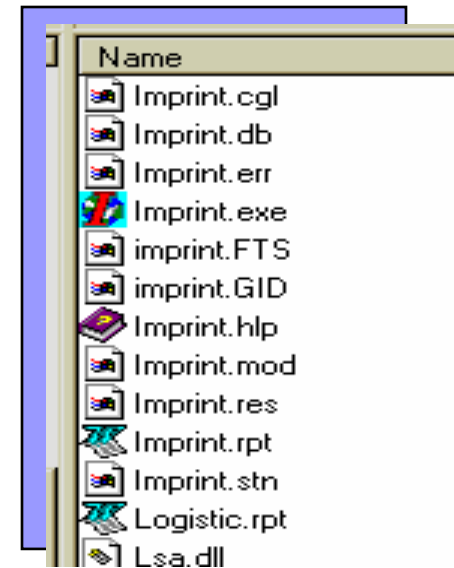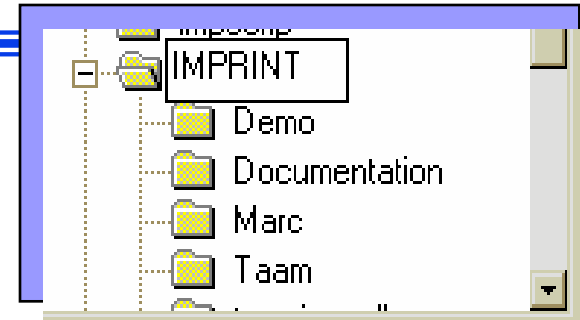
◆ ## What isn't: Your analysis by name!

Saving Your Analysis

- Save early, save often*
  *from the top-most window

- Save again as you exit

- Saving your analysis

- Saving your network diagram & information

- When in doubt, save

- Reminders are legitimate!
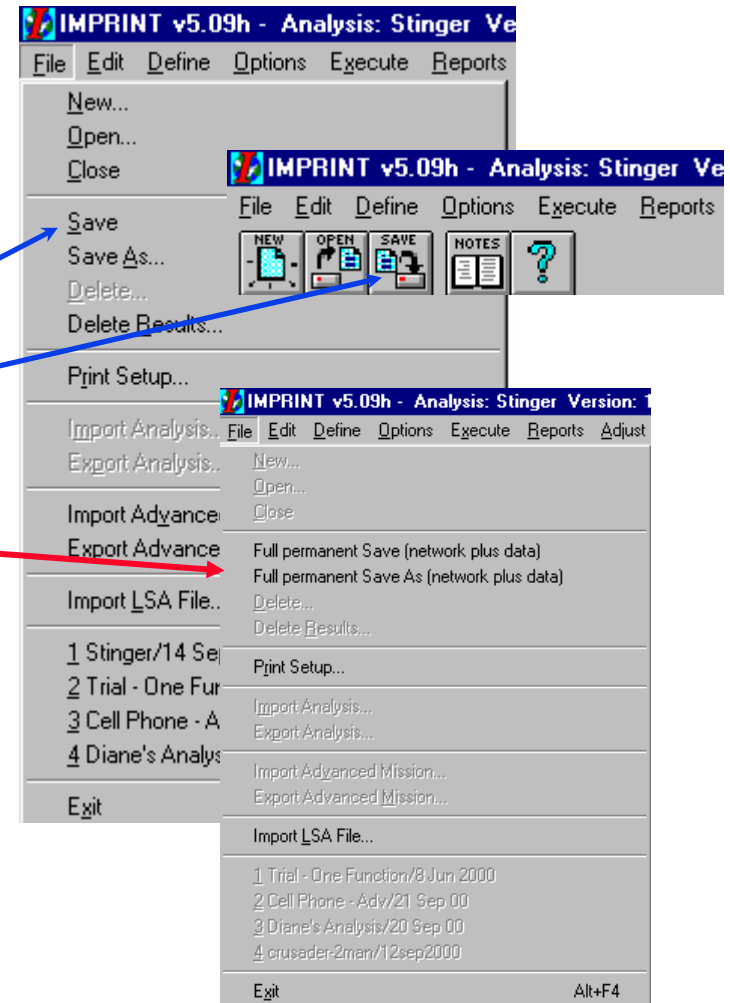
◆ To Import -
– Close the open analysis
– Select "Import"
– Browse until you find the one you're looking for
– To access the analysis, you must then open it
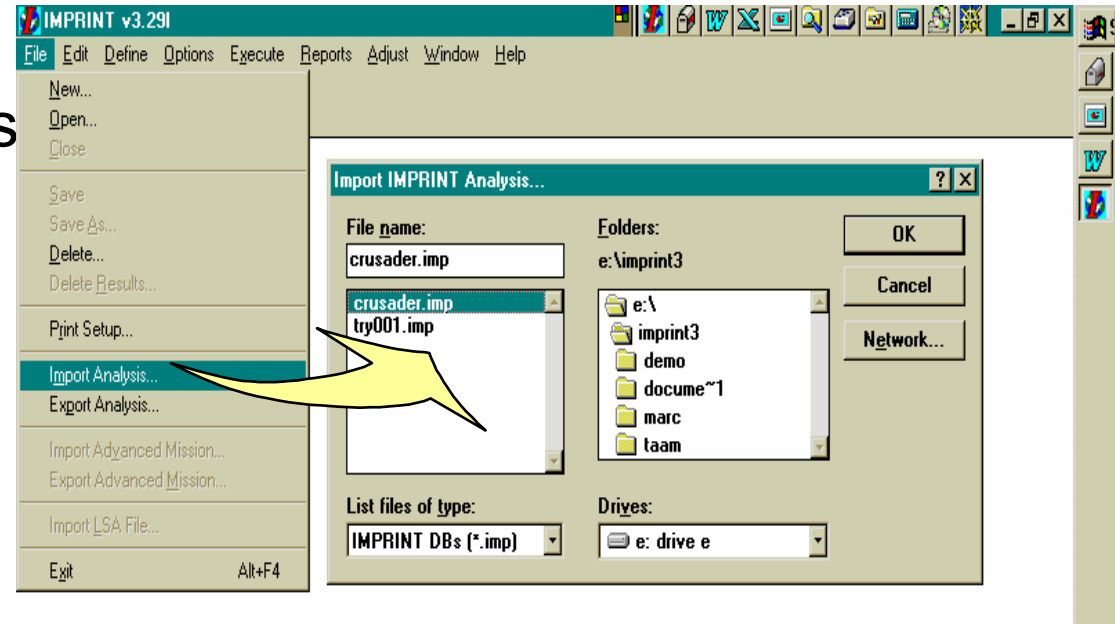
◆ To Export -
– Close your analysis if you have one open
– Select Export option
– Create export file using Windows naming conventions
– On hard drive or on disk
– File name <u>does not have to</u> = analysis name

In IMPRINT, it's an analysis. Out of IMPRINT, it's a .imp file.

Introduction to Advanced Modeling

Advanced Modeling vs. Advanced workload

◆ Advanced modeling capabilities allow you greater flexibility in controlling the sequence of events in your model

  – Effects tab

◆ Advanced workload is another model for predicting workload based on multiple resource theory
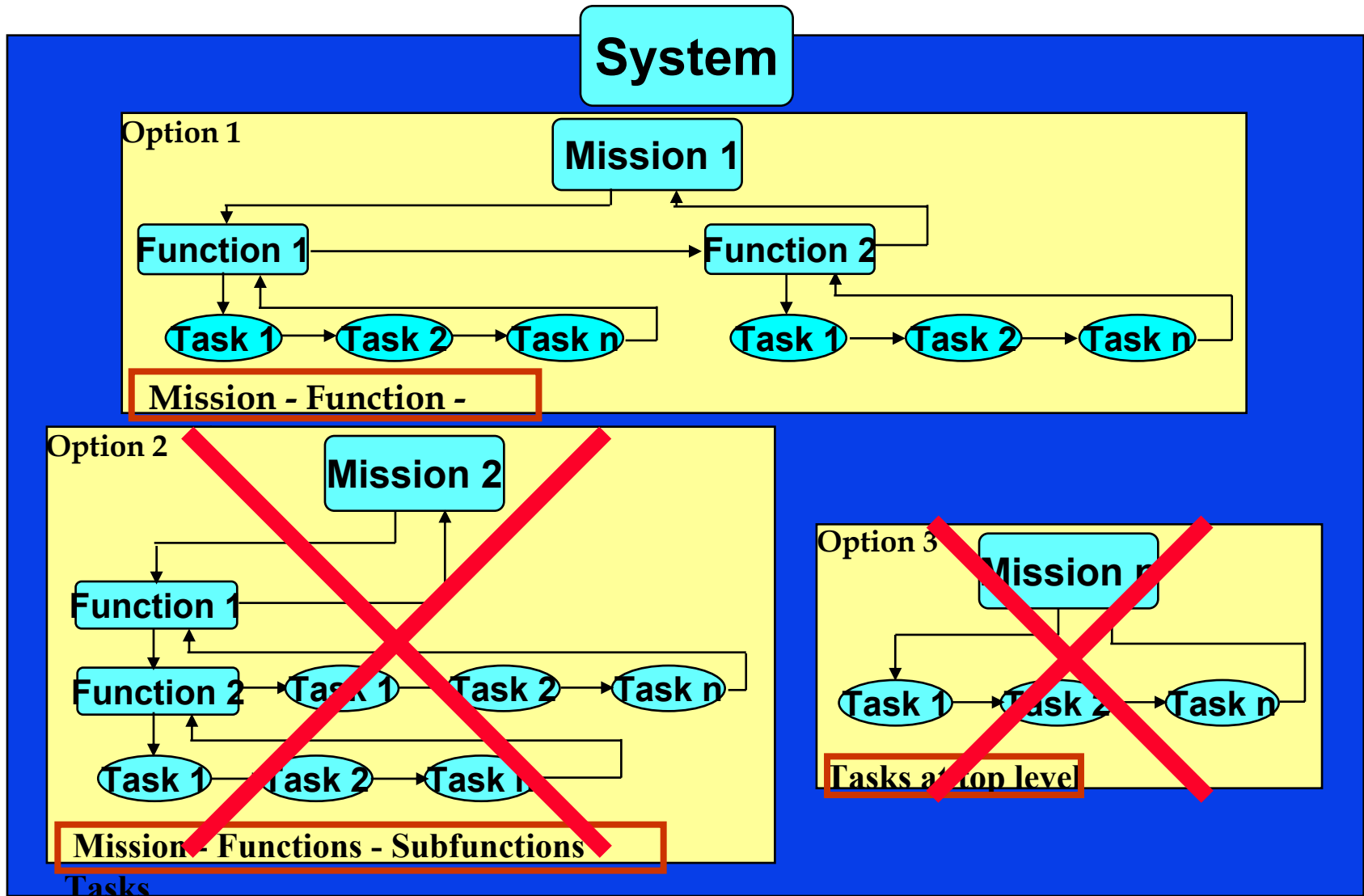
Multiple Resources Theory of Mental Workload

| Mission Tasks | → | Which Brain Resources Involved? | → | Degree of Resource Use? |

1. monitor alarms

2. decide response action

3. pull trigger

.

.

.

n. task n

Visual

Cognitive

Auditory

Motor

Speech

→

Speech

Visual

Auditory

Motor

Cognitive

0.0	No Cognitive Activity
1.0	Automatic (simple association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation/Judgment (consider single aspect)
5.3	Encoding/Decoding, Recall
6.8	Evaluation/Judgment (consider several aspects)
7.0	Estimation, Calculation, Conversion

◆ Critical Path

◆ Operator Activity

◆ Operator Workload

◆ Overload

◆ Channel Conflict

◆ Task Timeline

◆ CrewStation Workload

◆ User Snapshot

REPORTS

Branching Logic and Expressions

- Variables

- Mathematical and Logical Expressions

- Beginning Effects

- Ending Effects

- Release Conditions

- Data Collection

- ◆ Most variables are defined by the user to represent conditions or parameters
  - – Examples
    - » Resource availability
    - » Entity status
- ◆ Variable values can affect model execution
- ◆ Variable values are data to be collected

**Similar to a cell in a spreadsheet
or an algebraic expression**

$$y = mx + b$$

	A	B	C	D
1				
2	Table			
3			Path1	
4				
5	Target			Speed
6				
7				

◆ Real

◆ Integer

◆ Arrays

   – Integer or real

   – 1, 2, or 3 dimensions

   – Indexed by a variable during a simulation

   – Think of them as tables with as many columns as you need

◆ tag

- – A system variable that keeps track of the number of the entity being acted on by any event at any time

- – Once you assign a value, it gets carried through

- – In IMPRINT, tag denotes the operator number

◆ clock
- – The current simulation time
- – Starts at zero
- – No expected resemblance to "real time"

◆ run
- – When you have multiple runs of the network, this tells you which run you're in
- – Can be used to change conditions across runs

◆We recommend that variable names start in Caps

◆System variables are usually lower case

◆Variables are global and if you change a system variable unintentionally, it will impact the model run

◆ Exception is counters

SpeedRec[n]   Target   n   clock

◆ Expressions are used to initially set or change variable values in Micro Saint & WinCrew models

– Examples

» To set and change resource availability

» To set and change entity states

◆ Two general types - mathematical and logical expressions

◆ Operators

( ) grouped operations

^   exponentiation

*   multiplication

/   division

% remainder division

+   addition

-    subtraction

clock/60

Speed/LapDist

Laps*LapDist

n + 1

◆ Logical operators

>   greater than

<   less than

>= greater than or equal to

<= less than or equal to

<> not equal to

| logical or

&   logical and

= = equal to (e.g., if a== b then...)

: = assignment

◆ Logical statements

```
if
then
else
    if a>b then Time:=5 else Time:=7;
while ... do
    while i < 5 do Type[i] := 1, i=i+1;
```

◆ Adjustment operators

+=   Increment by adding

- =   Increment by subtracting

/ =   Increment by dividing

* =   Increment by multiplying

n+=1   **m-=1**

n=n+1   **m=m-1**

◆ Separators

> **;**   end of expression
>
>   e.g., a:=1;
>
> **,**   separates assignments within expressions
>
>   e.g., if a<1 then b:=5 , c :=6 else b:=4 , c:=2;

Comments are placed in curly brackets.
Note: All code must end in a ;

{This is an example of comments}1;

{When this task ends increment the task counter by 1} Taskcount+=1;

- ◆ Allows task to execute
- ◆ Establishes rules for task execution
- ◆ Condition must be true - 1=true, 0=false
- ◆ Can include multiple conditions
- ◆ Typically involves logical expressions

◆ Beginning effects

– What model conditions change as a result of a task beginning to execute

  ◆ e.g., resources are used, counters are incremented

◆ Ending effects

– What model conditions change as a result of a task completing execution

  ◆ e.g., resources are free, counters are decremented

◆ **MicroSaint executes events in this order**

    –   Release conditions

    –   Mean time

    –   Beginning Effects

    –   Ending Effects

        •   Succeeding task(s)

◆ Expressions that are inserted into model execution at selected clock times

◆ Can be used to cause task execution

◆ Used commonly to

– Establish initial conditions of the system

– Insert system changes (e.g., arrival rates)

"Start" and "Stop" Logic

Develop Your Own Analysis

◆ Pick a Topic

◆ Develop a Question and Hypothesis

◆ Determine Measures
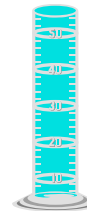
◆ Identify Functions and Tasks

◆ Build your Model
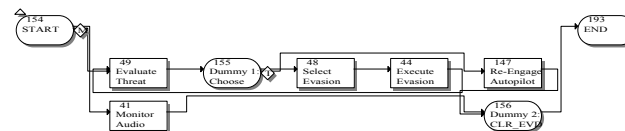
Yeah!!

So What??

◆ **Did it do what you wanted it to?**

  - First step is verification and debugging

◆ **How are you going to evaluate the results?**

  - Complete the analysis step

◆ **Is this realistic?**

  - Validate the model

Debugging Tools

Step 1. Run model in IMPRINT
Step 2. Open the IMPRINT directory
Step 3. Open the correct version of MicroSaint
      - VACP model – vacpsaint.exe
      - Advanced model – crewsaint.exe
      - Goal model – goalsaint.exe
Step 4. Open the model
      - VACP model – imprint.mod
      - Advanced model – saint.mod
      - Goal model – cart.mod
Step 5. Run the model – Single step using Ctrl t

Note: No changes will be saved. You must go back
      and make the changes in IMPRINT.

Event Queue

cart.mod : Event Queue

Time	Tag	Group	Type	Event
1.89587	1	0	⊂→	10001 Cmdr Driver
1.89587	0	0	⊟	215 QUEUE FOR: Continue
1.89587	9990	0	→⊂	9990 goalstat1
1.89587	9999	0	→⊂	9999 trigger parser
1.89587	0	0	⊟	206 QUEUE FOR: Decide Path & Speed CD
1.89743	0	0	⊂→	205 Recognize Path CD
1.90091	0	0	⊂→	217 Assess Vehicle Function CD
1.90297	0	0	⊂→	214 Assess Vehicle Motion CD
1.91778	0	0	⊂→	212 Assess Vehicle Orientation CD
1.92436	0	0	⊂→	199 Don't Steer
2.03703	0	0	⊂→	198 Coast CD
6.08793	155	0	⊂→	156 Send voice message CD
10.08793	168	0	⊂→	170 monitor + update IVIS (random 1-10s) Gunner
11.60162	81	0	⊂→	89 CD inputs report via IVIS
23.31807	176	0	⊂→	187 crew comm2 continues delay random

Snapshots of Execution

- ◆ Used to collect data during a model run
- ◆ Each snapshot defines variables to be stored during execution
- ◆ Data collection can be triggered on
  - Task execution
  - Entities going into or departing from queues
  - Clock time
  - End of the run
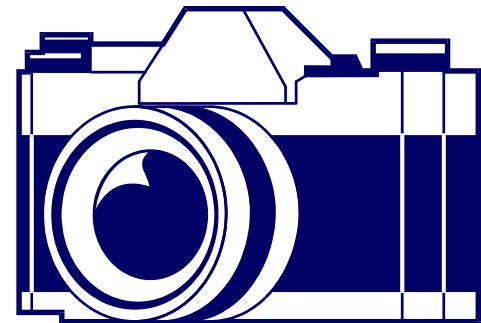
What is mental workload?

calories burned

An Example

◆ Drivers slowing down to talk on their cell phone

◆ Accident rates of drivers using cell phones approaches that of drivers under the influence of alcohol

◆ If you reduce crewsize then some tasks must be automated or redistributed among remaining crew positions

- Reallocation of tasks is likely to increase workload, thus increasing the potential for performance failures and errors.

- Poorly designed automation can also increase workload and thus the potential for human errors.

◆ Workload Definition

– There is no universally agreed-upon definition

– Today, however, there is generally agreement that, essentially, workload is

» *the perceived relationship between the amount of mental processing capacity or resources and the amount required by the task*

*Gopher & Donchin, 1986, Hart & Staveland, 1988
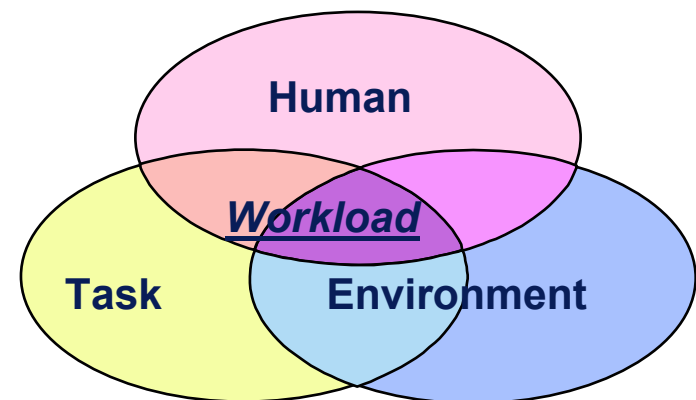
◆ Sustained low workload (underload) leads to boredom, loss of situation awareness, and reduced alertness.

◆ Sustained high workload (overload) leads to fatigue.

◆ Workload peaks lead to dropped tasks, increased task time, cognitive tunneling, and increased errors.

◆ These factors reduce crew performance, system performance, and contribute to mission failure

Achieve evenly distributed, manageable workload.
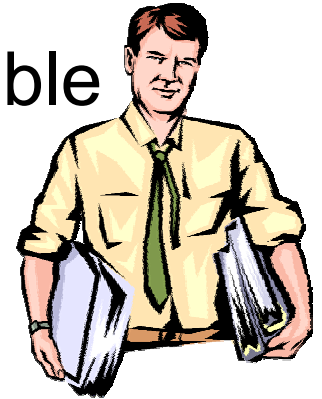
Avoid both overload and underload.
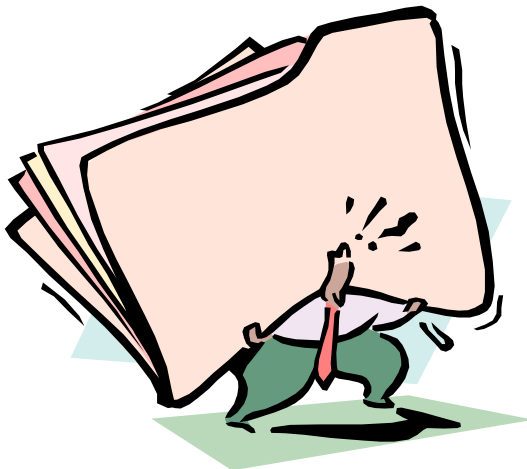
Various Mental Workload Measurement Approaches

empirical

- physiological
- primary task
- secondary task
- subjective rankings

analytical

- workload modeling- IMPRINT

◆ Workload modeling of human behavior is a technique that has been used to *predict* workload levels. Many different models have been proposed to model human behavior and measure workload.

◆ Workload modeling of human behavior is a technique that has been used to *predict* workload levels.

   – IMPRINT can be used to model and predict mental workload.

HARDMAN III, MAN-SEVAL

Crewcut

ten years

IMPRINT

WinCrew

IMPRINT v3.0

WinCrew, commercial

◆ workload predictions are used to estimate operator performance and its effect on system performance

What is advanced IMPRINT workload?

Mission Tasks → **Which Brain Resources Involved?** → **Degree of Resource Use?**

1. monitor alarms
2. decide response action
3. pull trigger
.
.
.
n. task n

- Visual
- Cognitive
- Auditory
- Motor
- Speech

Speech
Visual
Auditory
Motor

Cognitive

Value	Description
0.0	No Cognitive Activity
1.0	Automatic (simple association)
1.2	Alternative Selection
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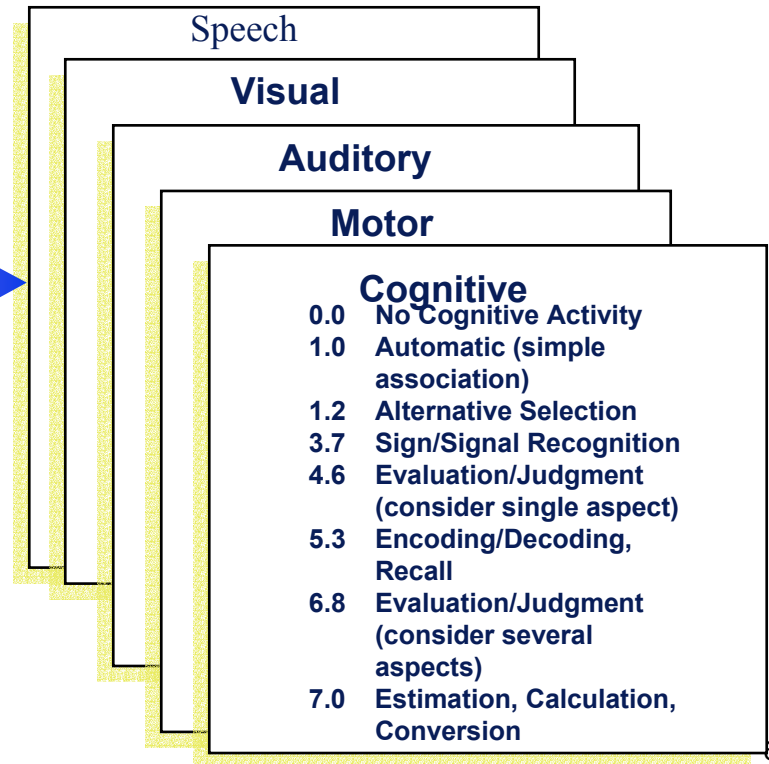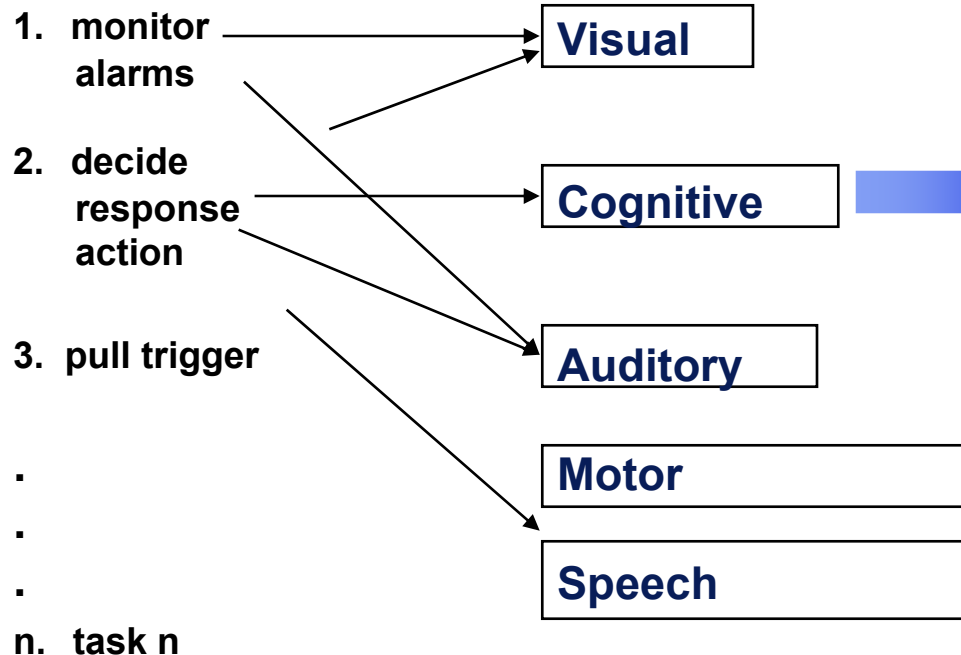
ADVANCED WORKLOAD CALCULATION:

$$W_T = W_{STD} + (W_{WCC} + W_{BCC})$$

Where:

W_T = Instantaneous Workload at Time T

W_{STD} = Workload attributable to the demands of all operator's tasks at time T (Single Task Demands)

W_{WCC} = Workload attributable to Within-Channel Conflicts (Within and between tasks)

W_{BCC} = Workload attributable to Between-Channel Conflicts (Between tasks only; within tasks may see improved performance "S-C-R")

* Adapted from W/Index North & Riley, 1988

Workload & Crewstation Parameters

Resources

◆ Default set

- – Visual
- – Auditory
- – Motor
- – Speech
- – Cognitive

◆ Add up to 5 more

Interfaces

◆ Controls and displays in your design

◆ Don't get carried away!
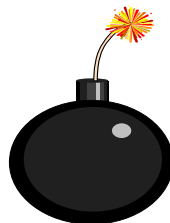
Be prudent!

◆ Pair resources with interfaces

◆ Assign resource interface pairs to tasks

◆ Estimate single task demands for tasks

Pop-up scales accessed by double-clicking the cell

- BIG contributor to workload score

- Penalties for using resource interface pairs

- Cell values range from 0.00 -1.00

- Double click on row header provides "expert guidance" and default values

◆ Describes effort needed to perform task

◆ To help examine impact of workload during mission

◆ Results are combined across channels into one score

◆ Results consider inter- & intra-channel conflict

◆ Does dynamically impact performance

Time, Accuracy, Crew Allocation, Sequence

Workload Threshold

Workload Over Time

Scenario 1 - Tank Mission at run time 2411.2

0.0 START

f1 Prepare Vehicle
f3 TC setup
f6 TC Login

f5 Gunner setup
f8 Gunner Login

f35 Tactical planning
f18 TC + Gunner

f2 Tactical Road March
f9 TC Drive
f39 TC monitor C2
f42 TC Scan for
f44 Gunner Scan for

f31 Conduct Actions
f15 Engage Targets
f20 Gunner Engage
f17 Gunner Engage

f32 Perform support

f33 Hasty occupation
f36 Platoon Leader

f34 Displace to a
f21 TC override
f23 Gunner Change
f22 TC Change Mode on

f28 Drive, ext +
f24 Stop TC scan for
f29 Stop TC Driving
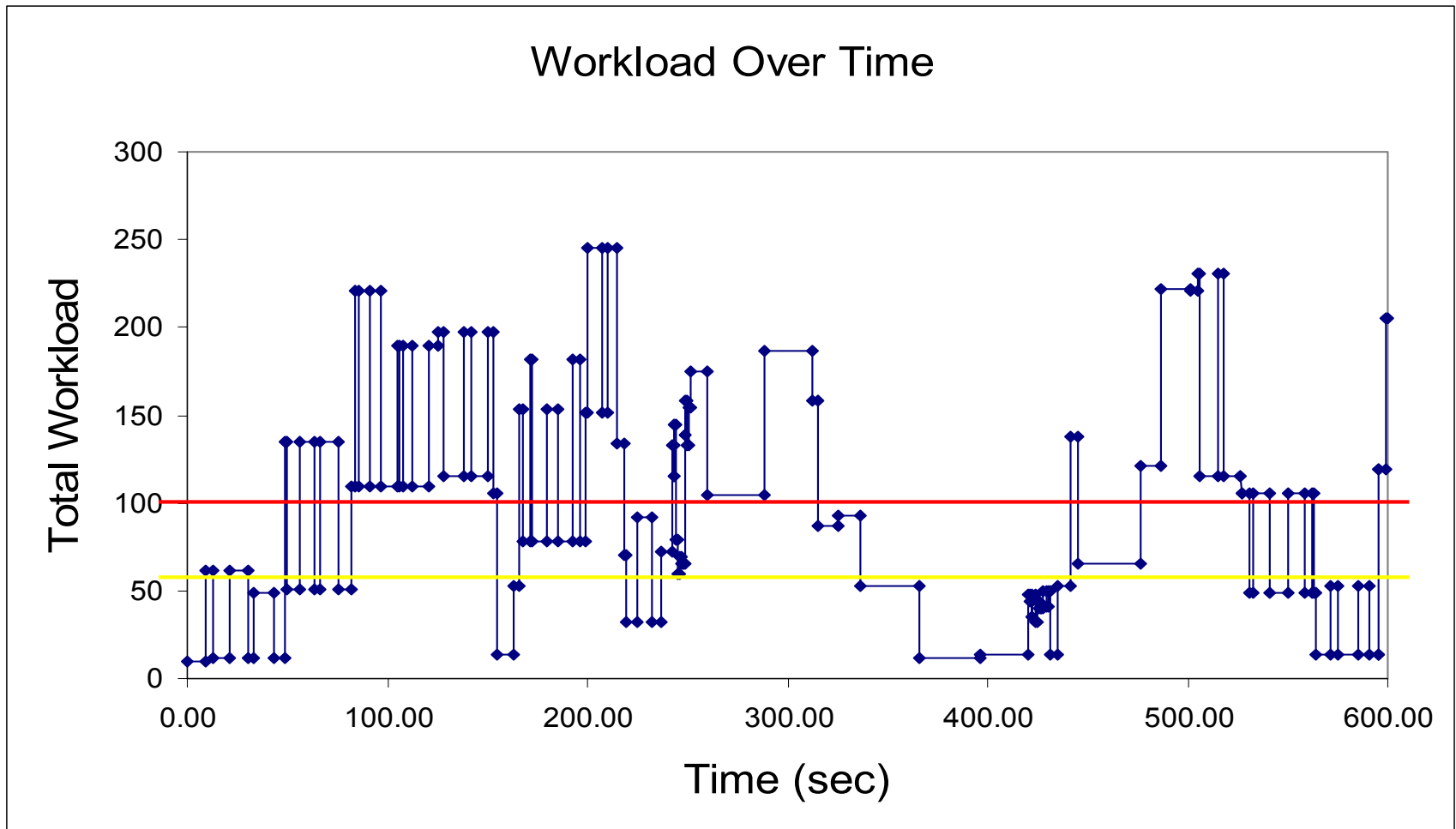**f26** Stop Gunner

0.999 END
f38 stop TC monitoring
f27 Stop crew commo

Movement to contact - function
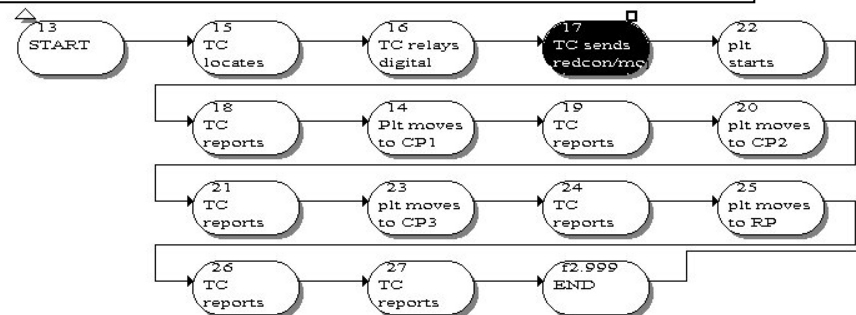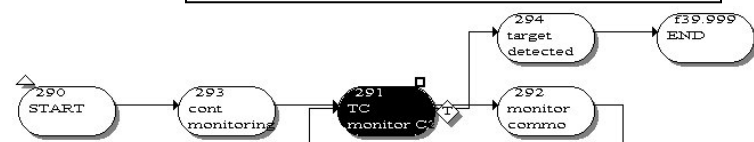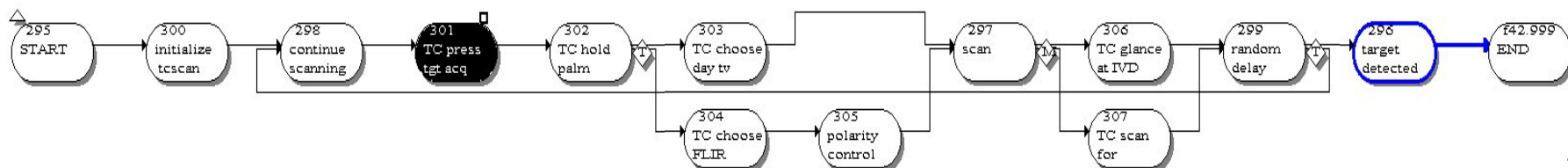
13 START

15 TC locates
16 TC relays digital
17 TC sends redcon/mo
22 plt starts

18 TC reports
14 Plt moves to CP1
19 TC reports
20 plt moves to CP2

21 TC reports
23 plt moves to CP3
24 TC reports
25 plt moves to RP

26 TC reports
27 TC reports
f2.999 END

Monitor C2 - function

290 START

293 cont monitoring
291 TC monitor C2
292 monitor commo
294 target detected
f39.999 END

TC Target Scan - function

295 START
300 initialize tcscan
298 continue scanning
301 TC press tgt acq
302 TC hold palm
303 TC choose day tv
304 TC choose FLIR
305 polarity control
297 scan
306 TC glance at IVD
307 TC scan for
299 random delay
296 target detected
f42.999 END

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Analysis of Results

- Critical Path
- Operator Activity
- Operator Workload
- Overload
- Channel Conflict
- Task Timeline
- CrewStation Workload
- User Snapshot

REPORTS

REDUCED, POOR AUTOMATION, GOOD ALLOCATION
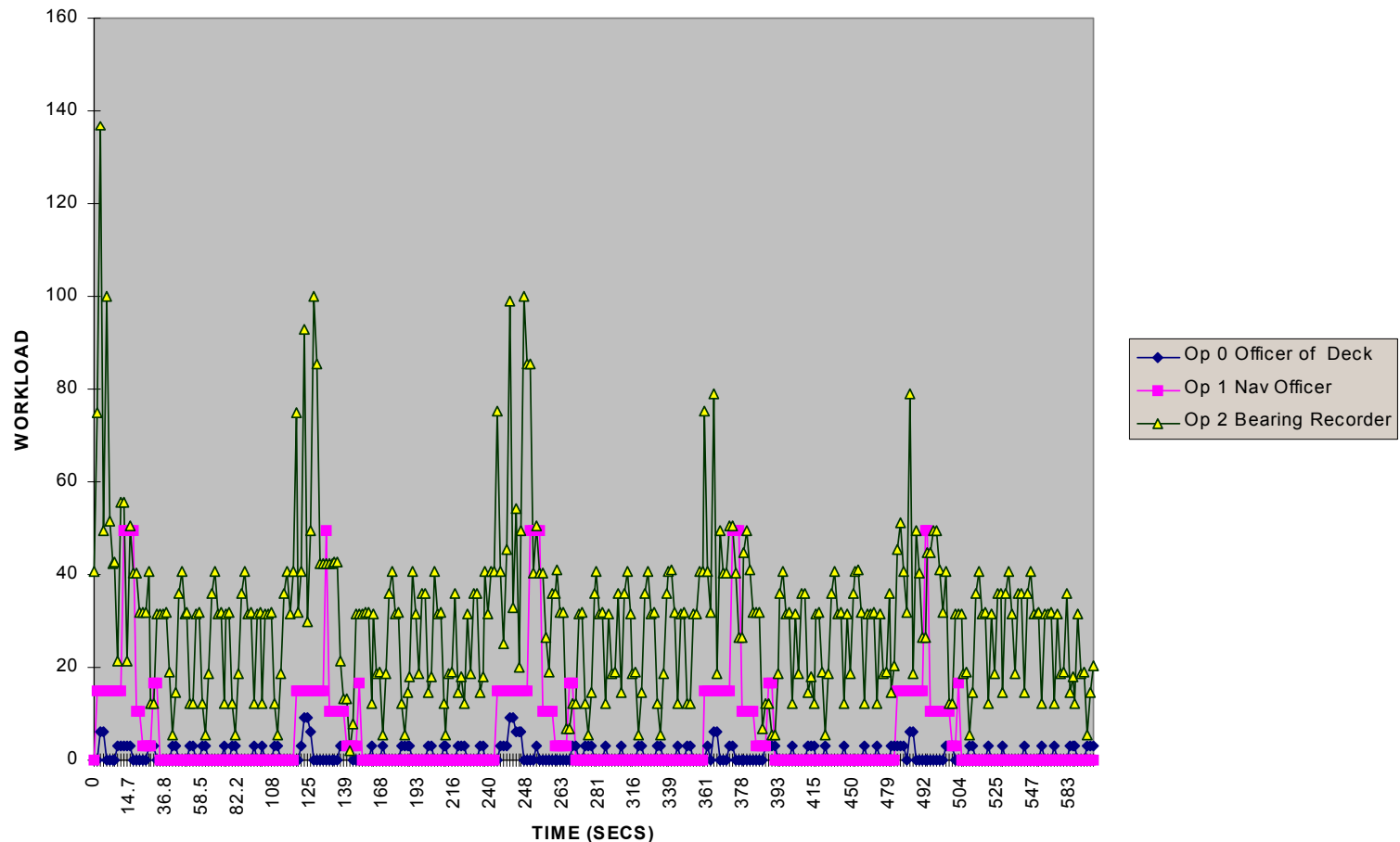
◆ Consider your audience

◆ Display your results accordingly

- Spreadsheets
- Tables
- Graphs

Results - spreadsheets

| Thresholds		Results					
T1 =	**60**	Number of Times over	**60**	**97**	Number of Times over	**100**	**59**
T2 =	**100**	Percent of time in	**60**	**39.8%**	Percent of time in overload	**100**	**24.0%**
		Max Workload Value		**283.9**	Min Workload Value		**7**

		T 1				T 2			
Time	**Workload**	**>?**	**Secs >**			**>?**	**Secs>**		
0	14.7	0	0			0	0		
3	58.01	0	0			0	0		
8	13.5	0	0			0	0		
9	54.6	0	0			0	0		
12	32.11	0	0			0	0		
14	38.67	0	0			0	0		
15.89	42.09	0	0			0	0		
16	**106.91**	1	2			1	2		
18	**244.18**	1	1			1	1		
19	**155.93**	1	2			1	2		
21	7	0	0			0	0		
23	29.66	0	0			0	0		
25	48.96	0	0			0	0		
25.12	**99.93**	1	3.88			0	0		
29	13.2	0	0			0	0		
31	14.7	0	0			0	0		
31.06	57.86	0	0			0	0		
34	**76.89**	1	0.69			0	0		
34.69	**163.74**	1	2.31			1	2.31		
37	**69.99**	1	2			0	0		

|	Combat	AutoScan	Baseline	Non-Combat
	T1 = **60**	T1 = **60**	T1 = **60**	T1 = **60**
Number of Times over T1	**112**	**91**	**97**	**50**
Percent of time in overload > T1	**46.9%**	**37.7%**	**39.8%**	**34.2%**
Max Workload Value	**244.18**	**287.02**	**283.9**	**245.82**
Min Workload Value	**7**	**3**	**7**	**7**
	T2 = **100**	T2 = **100**	T2 = **100**	T2 = **100**
Number of Times over T2	**69**	**44**	**59**	**29**
Percent of time in overload > T2	**28.3%**	**19.1%**	**24.0%**	**23.5%**

Workload Over Time
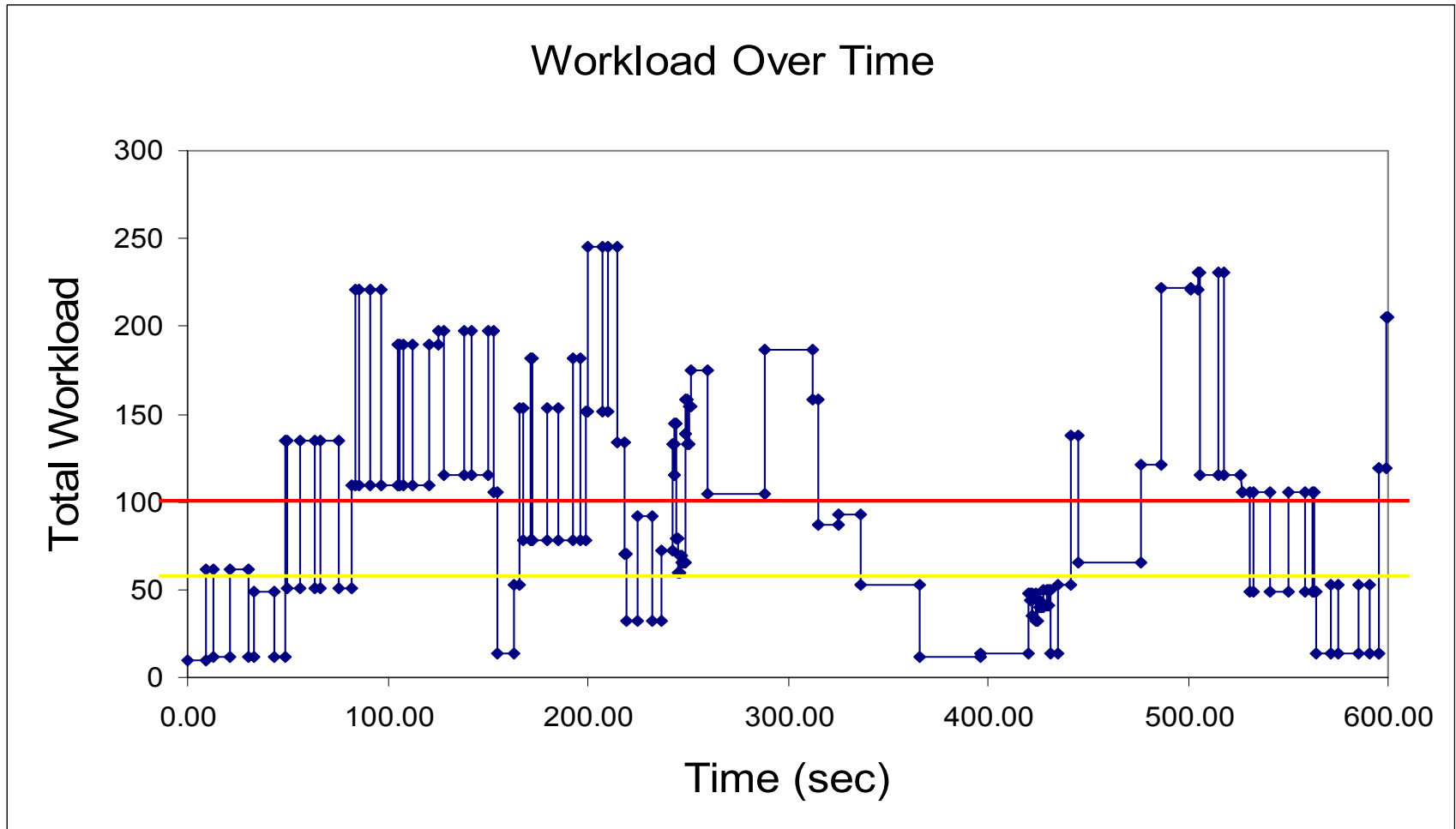
Goal Oriented Modeling

◆ Goal orientation

- – Option from VACP
- – Beginning & Ending Effects
- – Variable Catalog
- – Macros (User-Defined Functions)
- – Snapshots

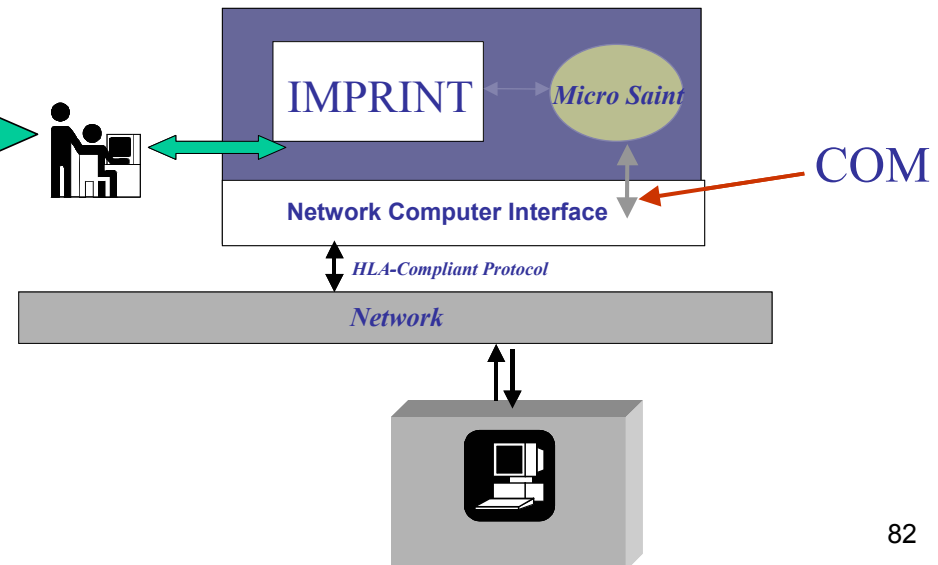◆ COM capabilities

- – Including HLA Middleware

◆ Access to tag
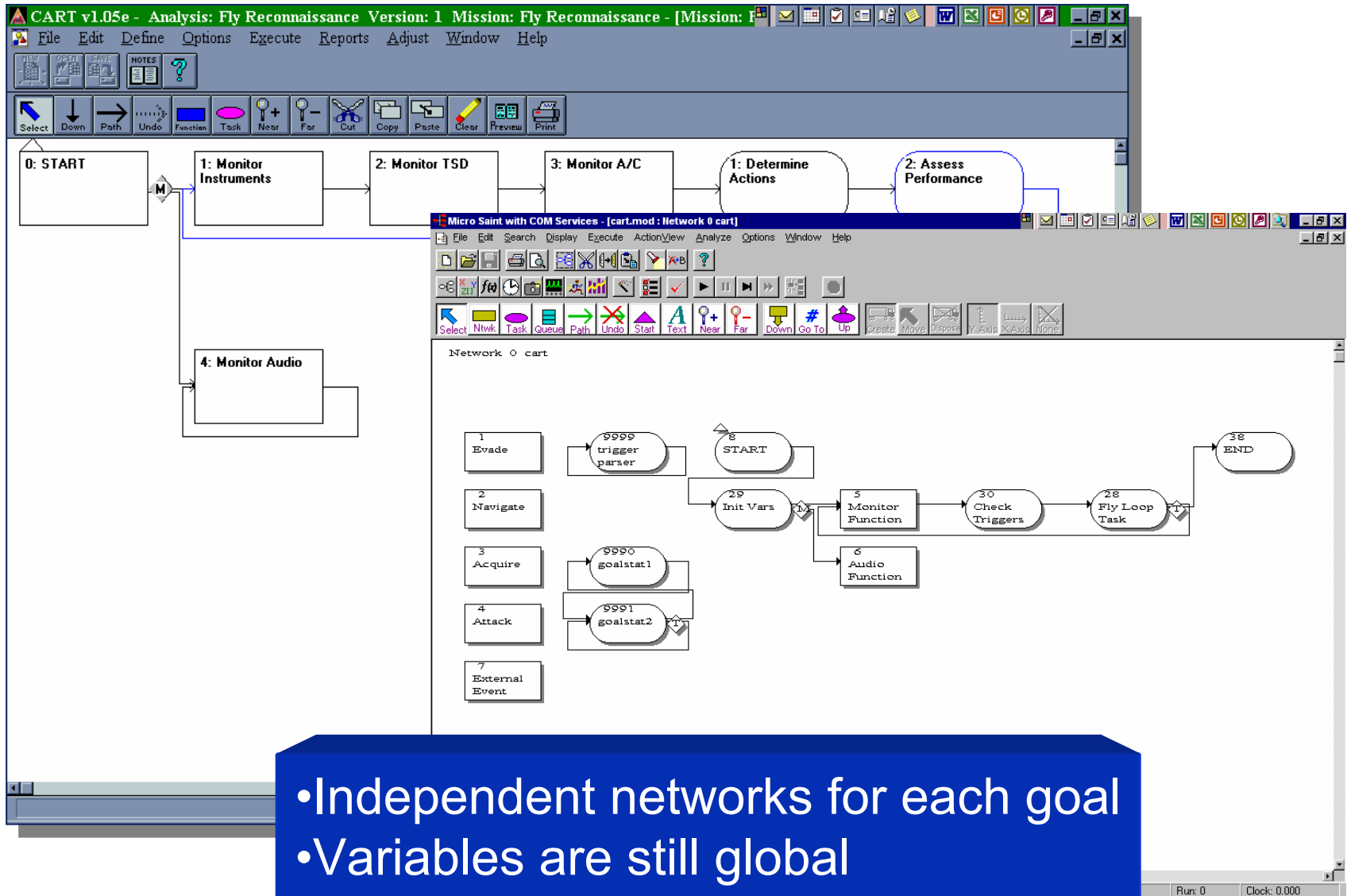
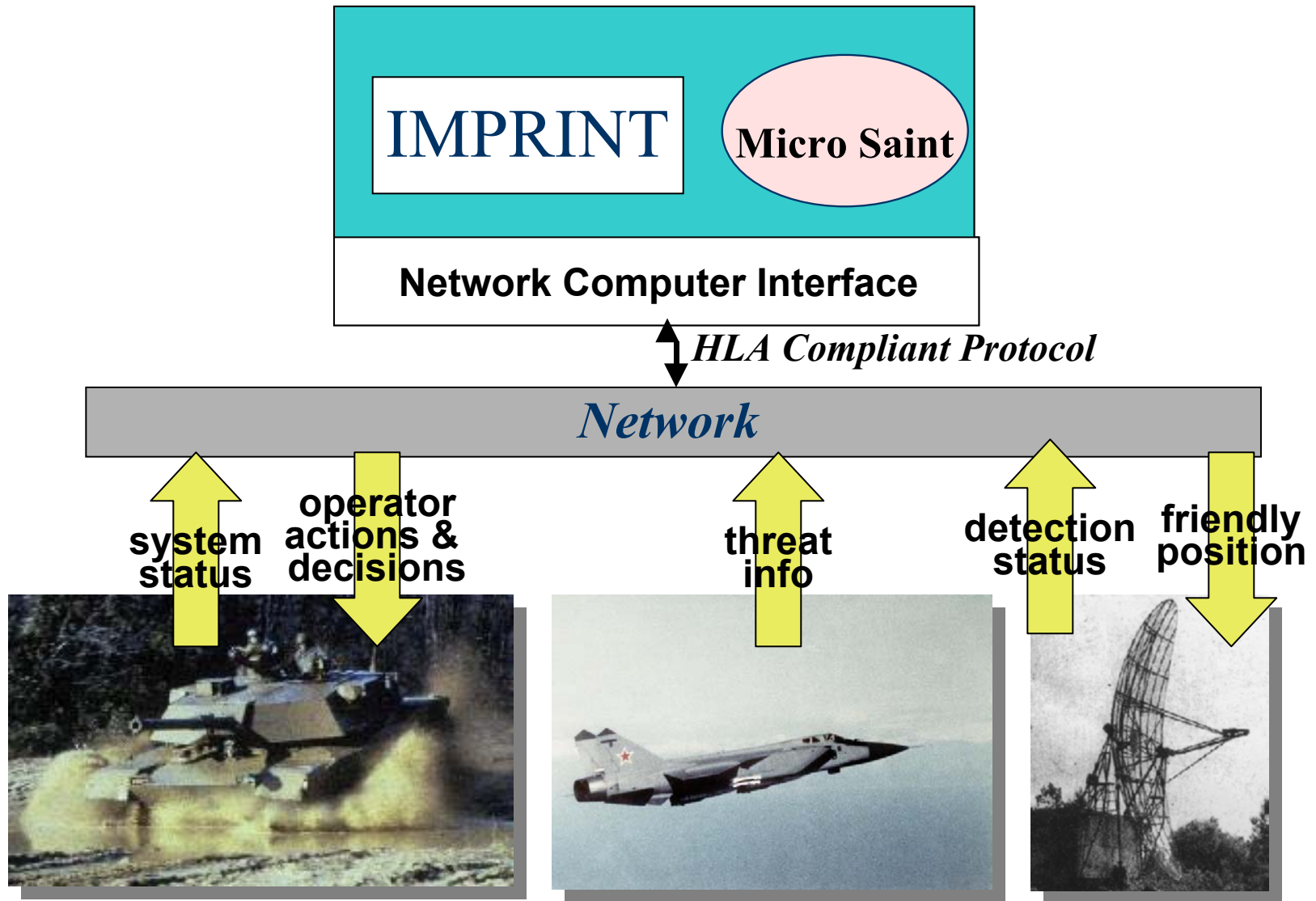•Independent networks for each goal
•Variables are still global

- **Trigger identification**

- **Trigger communication**

- **Task interruption**

- **Task restart vs. task resume**

IMPRINT   **Micro Saint**

Network Computer Interface

HLA Compliant Protocol

Network

system status   **operator actions & decisions**   **threat info**   **detection status**   **friendly position**
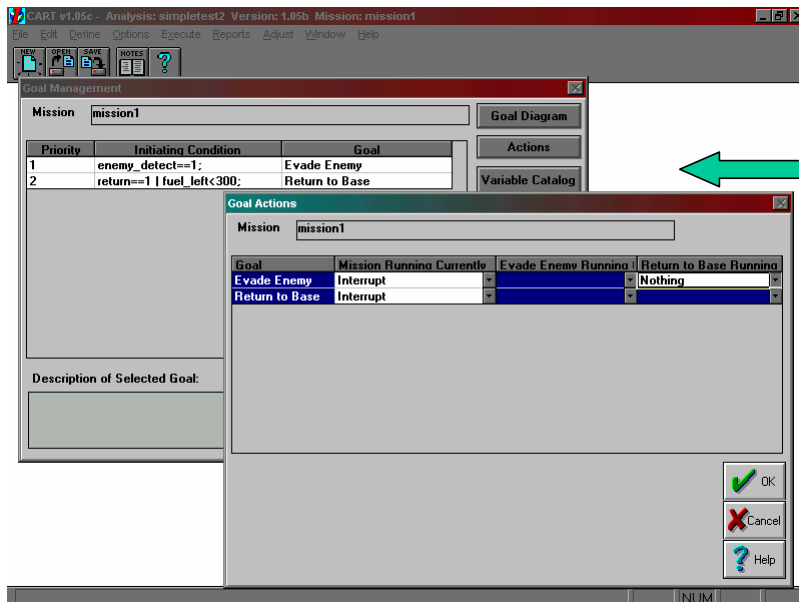
◆ **AF Validation Success Story**

– Wright Pat SIMAF Virtual Strike Warfare Environment

– Time critical targeting (SCUD Hunt) mission

– HPM vs. Eight pilots (F16 and A10)

– Overall kills of ground targets in the time critical scenario was virtually the same for both the model and pilots (100% and 98%, respectively)

– HPM accounted for 61 percent of the behavior of the pilots in the simulation environment

– New tactic discovered: Coordinated use of synthetic aperture radar (SAR) and targeting infrared (TIR) imaging system

1. **When you want VACP workload and the ability to use effect modeling**

2. **When you want to represent human behavior using goals**

3. **When you need to talk to other simulations**

You can switch from VACP or Advanced to Goal oriented with caveats!

Review Advanced Modeling Capabilities

◆ Variables

◆ Mathematical and Logical Expressions

◆ Beginning Effects

◆ Ending Effects

◆ Release Conditions

◆ Data Collection

Comments are placed in curly brackets.

Note: All code must end in a ;

{This is an example of comments}1;

{When this task ends increment the task counter by 1} Taskcount+=1;

◆ Allows task to execute

◆ Establishes rules for task execution

◆ Condition must be true - 1=true, 0=false

◆ Can include multiple conditions

◆ Typically involves logical expressions

◆ Beginning effects

– What model conditions change as a result of a task beginning to execute

◆ e.g., resources are used, counters are incremented

◆ Ending effects

– What model conditions change as a result of a task completing execution

◆ e.g., resources are free, counters are decremented

◆ MicroSaint executes events in this order

   – Release conditions

   – Mean time

   – Beginning Effects

   – Ending Effects

      • Succeeding task(s)

◆ Expressions that are inserted into model execution at selected clock times

◆ Can be used to cause task execution

◆ Used commonly to

– Establish initial conditions of the system

– Insert system changes (e.g., arrival rates)

Step 1. Run model in IMPRINT
Step 2. Open the IMPRINT directory
Step 3. Open the correct version of MicroSaint
- VACP model – vacpsaint.exe
- Advanced model – crewsaint.exe
- Goal model – goalsaint.exe
Step 4. Open the model
- VACP model – imprint.mod
- Advanced model – saint.mod
- Goal model – cart.mod
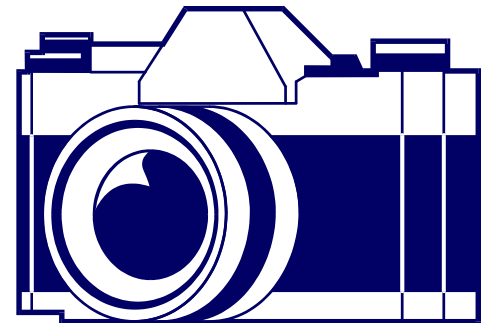Step 5. Run the model – Single step using Ctrl t

Note: No changes will be saved. You must go back and make the changes in IMPRINT.

cart.mod : Event Queue

Time	Tag	Group	Type	Event
1.89587	1	0	○→	10001 Cmdr Driver
1.89587	0	0	目	215 QUEUE FOR: Continue
1.89587	9990	0	→○	9990 goalstat1
1.89587	9999	0	→○	9999 trigger parser
1.89587	0	0	目	206 QUEUE FOR: Decide Path & Speed CD
1.89743	0	0	○→	205 Recognize Path CD
1.90091	0	0	○→	217 Assess Vehicle Function CD
1.90297	0	0	○→	214 Assess Vehicle Motion CD
1.91778	0	0	○→	212 Assess Vehicle Orientation CD
1.92436	0	0	○→	199 Don't Steer
2.03703	0	0	○→	198 Coast CD
6.08793	155	0	○→	156 Send voice message CD
10.08793	168	0	○→	170 monitor + update IVIS (random 1-10s) Gunner
11.60162	81	0	○→	89 CD inputs report via IVIS
23.31807	176	0	○→	187 crew comm2 continues delay random

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◆ Used to collect data during a model run

◆ Each snapshot defines variables to be stored during execution

◆ Data collection can be triggered on

- Task execution

- Entities going into or departing from queues

- Clock time

- End of the run

Goal Matrix

Goal Management

Mission: Fly Reconnaissance

Priorit	Initiating Condition	Goal
1	threat_present==TRUE & mission_time_left < 14.5;	Evade
2	target_present==TRUE & evade_status == FALSE;	Attack

Triggering conditions (from internal and external simulations)

Goal Diagram
Actions
Variable Catalog
Add Goal
Cut Goal
OK
Cancel
Help

Description of Selected Goal:

◆ **When a trigger comes true:**

– Look UP the matrix to see if a higher priority goal would suspend or halt it. If so, don't start it, but keep trying.

If not:

– Look DOWN the matrix and implement the actions for all lower priority goals

◆ **When a goal ends normally, gets halted or gets suspended:**

– Resume anything it suspended UNLESS a higher priority goal would halt it. If so, halt it. If a higher priority goal would suspend it, then suspend it.

Review of IMPRINT Capabilities

IMPRINT MODULES	DEFINE MISSION			DEFINE EQUIPMENT	DEFINE SOLDIER	DEFINE SUPPLY
	VACP Modeling	Advanced Modeling	Goal Oriented			
Interface Technique						
Data Entry				√	√	√
Graphical Toolbar	√	√	√			
Embedding Coding		√	√			
Additional Capabilities						
VACP Workload	√		√			
Advanced Workload		√				
PTS	√		√	√		

CAPABILITIES

Wrap up and Discussion!

➡ Save ! Save! Save!

➡ Never too many DUMMIES…

➡ Naming Conventions

Who

- Any government agency
- Private industry with government contract
- Foreign government (case-by-case)

How

- Send request via e-mail or letter
- If private industry include government contract number and organization

Non-Distribution Form

- Keep track of users
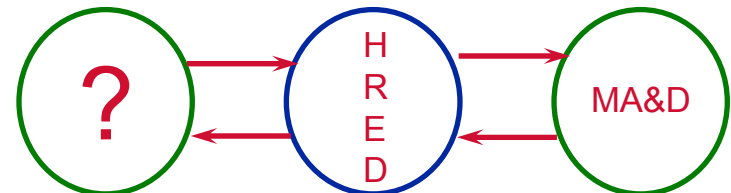- Reminder not to distribute

Software Distribution

ARL-HRED

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Maintain Database

◆ User comments
◆ "Bugs"
◆ "Fixes"

List of current IMPRINT users & interested parties

Send suggestions, comments, general information or questions regarding IMPRINT to

imprint@arl.army.mil

◆ Allender, L., Kelley, T. D., Salvi, L., Lockett, J., Headley, D. B., Promisel, D., Mitchell, D., Richer, C., and Feng, T. Verification, validation, and accreditation of a soldier-system modeling tool. Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting-1995, San Diego, pp. 1219-1223.

◆ Allender, L., Salvi, L., and Promisel, D.(June 1997). Evaluation of Human Performance under Diverse Conditions via Modeling Technology. Proceedings of Workshop on Emerging Technologies in Human Engineering Testing and Evaluation, NATO Research Study Group 24. Brussels, Belgium.

◆ Allender, L., Kelley, T., Archer, S., and Adkins, R., (1997). IMPRINT The Transition and Further Development of a Soldier-System Analysis Tool. MANPRINT Quarterly,Office of the Deputy Chief of Staff of Personnel, Vol. V, No. 1.

◆ Dahl, S., Allender, L., and Kelley, T., (1995) Transitioning Software to the Window Environment - Challenges and Innovations. Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting - 1995, San Diego, pp. 1224-1227.

◆ McMahon, R., Spencer, M., and Thornton, A. (1995). A quick response approach to assessing the operation performance of the XM93E1 NBCRS through the use of modeling and validation testing. Presented at the Military Operations Research Society Symposium.

◆ Micro Analysis & Design. Stressor Review Report: Enhanced Performance Degradation Factors and Upgrades for Improved Performance Research Integration Tool (IMPRINT) Version 5, Dynamics Research Corporation: 1-54.

◆ Mitchell, D. K. (2000). Mental workload and ARL workload modeling tools. (ARL-TN-161) Aberdeen Proving Ground, MD: Army Research Laboratory.

◆ Mitchell, D., Samms, C., Henthorn, T., Wojciechowski, J. (2003). Trade Study: A Two-Versus Three-Soldier Crew for the Mounted Combat System (MCS) and Other Future Combat System Platforms. (ARL-TR-3026) Aberdeen Proving Ground, MD: Army Research Laboratory.